

LLNL and SNL Dispersion Modeling and Assessment Tools

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Goal

Provide DOE/NNSA Consequence Management teams with a *unified tool set* and expertise for assessing...

- Radiological & nuclear source characteristics
- Prompt effects
- Meteorological flows
- Atmospheric dispersion and fallout
- Acute and chronic dose, affected population, injuries, casualties, and protective action guidelines
- Geographical information

Radiological and Nuclear Source Characteristic Models

- Explosive and non-explosive (liquid spray) radiological dispersal devices aerosol size distribution (SNL Source Term Encyclopedia)
- Nuclear detonation clouds (SNL AIRRAD, LLNL KDFOC)
- Buoyant explosive cloud rise model (SNL ERAD)
- Buoyant & momentum plume rise from fires or stack emission (LLNL LODI)

Prompt Effects

- Nuclear detonation effects (SNL's *NUKE* code):
 - Direct blast injury
 - Thermal radiation
 - Prompt radiation
 - Cratering and ground shock
 - Structural damage
 - Fallout
- Conventional explosive blast effects (SNL's *BLAST* code)



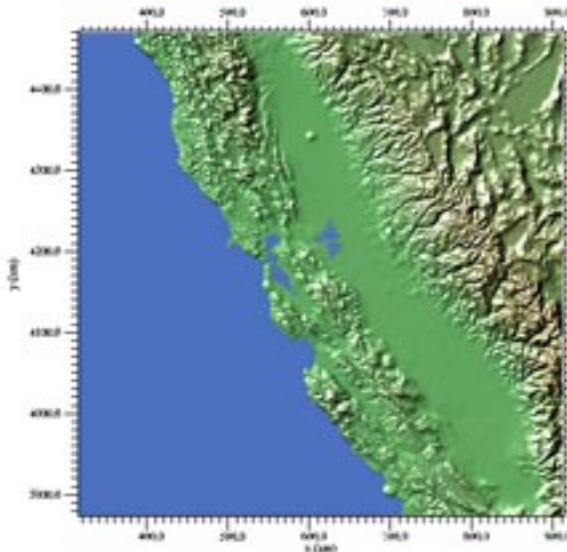
Meteorological Data & Modeling

LLNL's National Atmospheric Release Advisory Center (NARAC) facility provides...

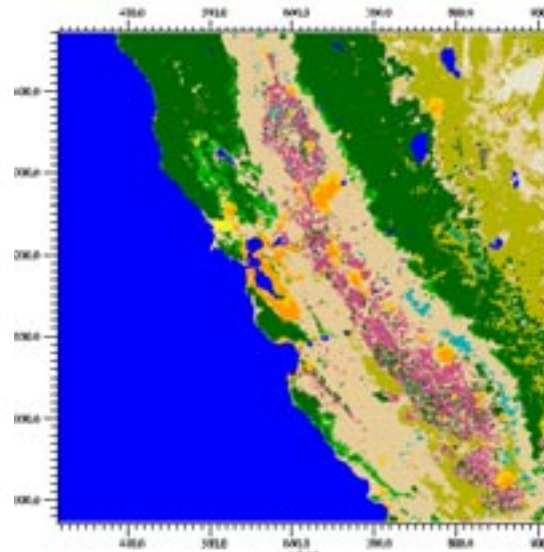
- Automated, real-time, global meteorological observation database
- Continental-scale and global-scale gridded meteorological analyses and forecasts from NOAA and Navy
- Regional-scale 3-D meteorological models run at NARAC:
 - ADAPT diagnostic (based on observations) meteorological model
 - NRL COAMPS mesoscale forecast model
 - Terrain and land-surface characteristics drive flow

Observed and forecast meteorological data distributed to deployed CM teams

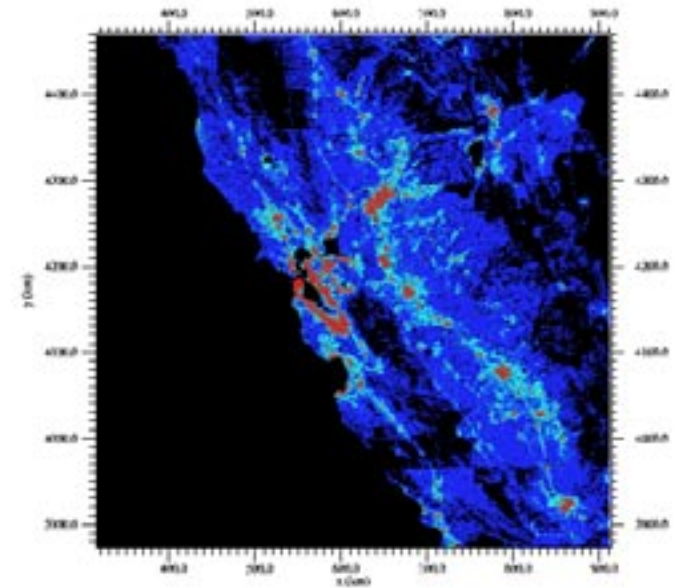
Geographic Databases



Terrain Elevation
database
is used for lower
boundary of 3-D
Meteorological flow
and dispersion
models



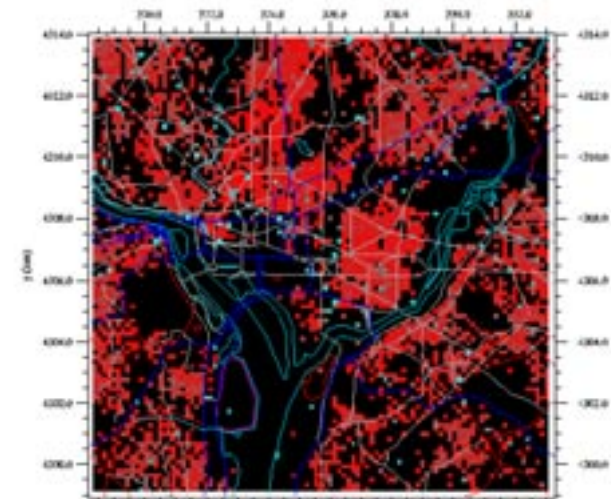
***Urban and Rural Land
Characteristics***
databases are used to
model their effects on
wind and turbulence



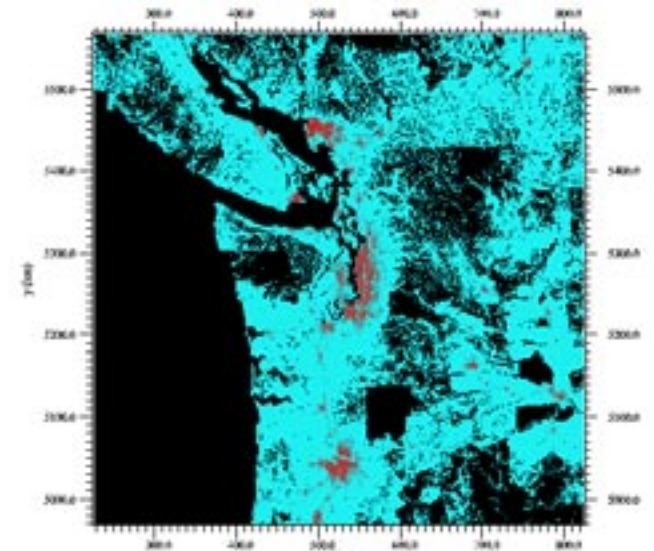
Population Density
databases are used
to estimate the
population affected
by the plume

Population Databases

- U.S. Census 2000 (and Claritas projected 2002) Data
 - Residential data
 - U.S. coverage
 - 150 meter resolution
- ORNL LandScan population data
 - ~1 km resolution
 - Global coverage
 - From best available census and ancillary data sources (day-night average)
- User-specified receptor population



Washington DC Census 2000 Population



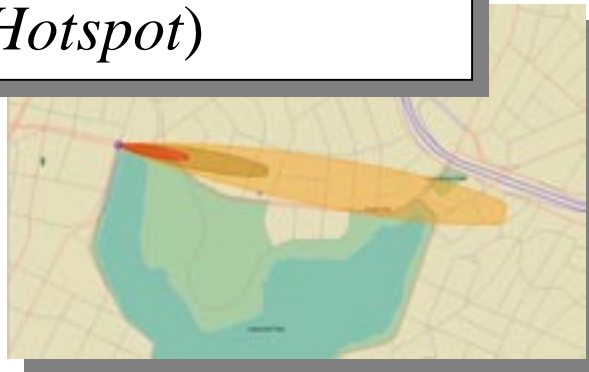
Pacific Northwest LandScan Population

Dispersion and Fallout Models

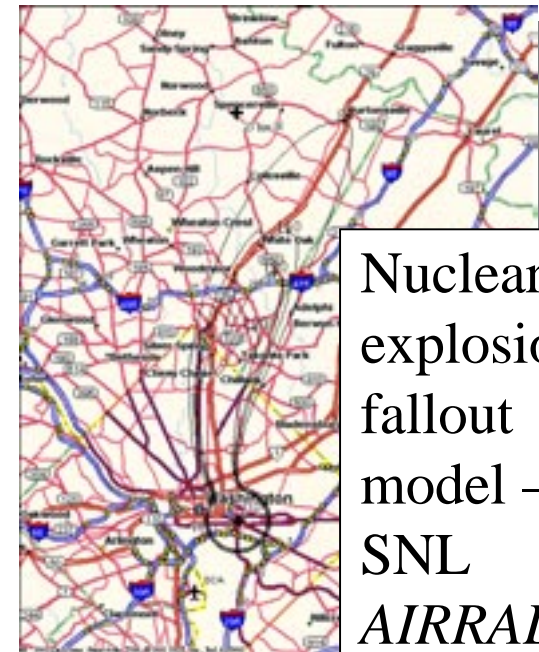
- Deployable local-scale, Gaussian-plume dispersion modeling tool (LLNL's HOTSPOT) for fast initial predictions with minimal input (constant wind)
- Deployable hybrid Monte-Carlo/Gaussian-puff atmospheric dispersion model with vertical variation in meteorological data (SNL's ERAD)
- NARAC home-team 3-D Monte Carlo particle dispersion model (LLNL/NARAC's LODI) with terrain effects
- Nuclear explosion local fallout models (SNL's AIRRAD & LLNL's KDFOC)

Fast-running Local Dispersion Modeling Tools for Deployed Use

Gaussian-plume model (LLNL *Hotspot*)



Sandia National Laboratory hybrid particle-puff dispersion model — SNL *ERAD*

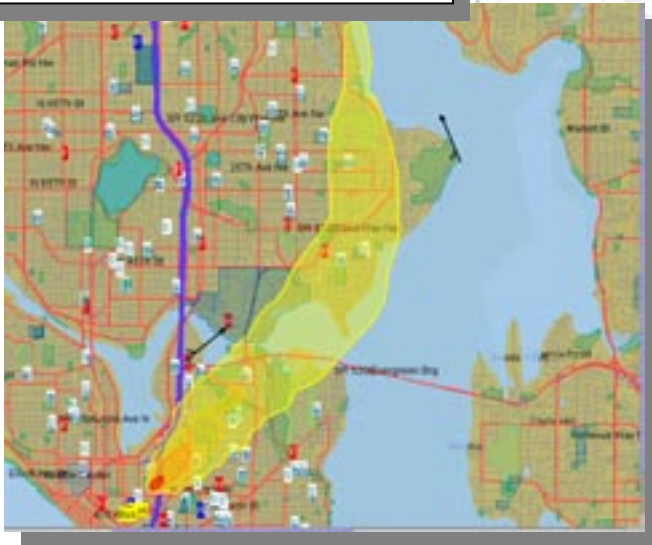
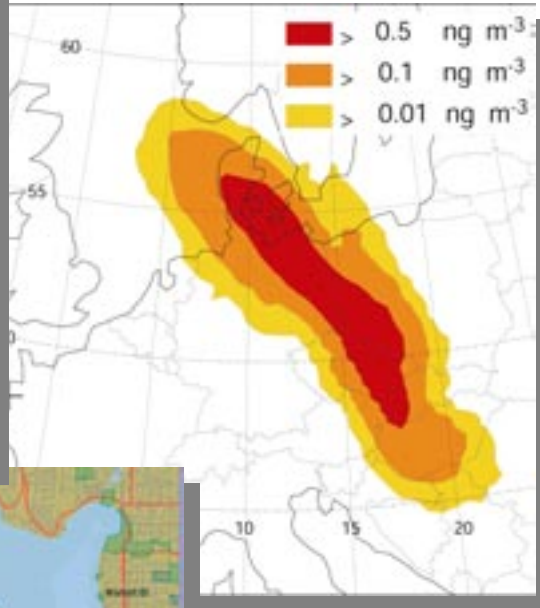


Nuclear explosion fallout model — SNL *AIRRAD*



LLNL/NARAC Atmospheric Modeling Tools

LLNL NARAC 3-D
Regional-scale and
Long-range
Meteorological and
Dispersion Models:
NRL *COAMPS* and
LLNL
ADAPT/LODI

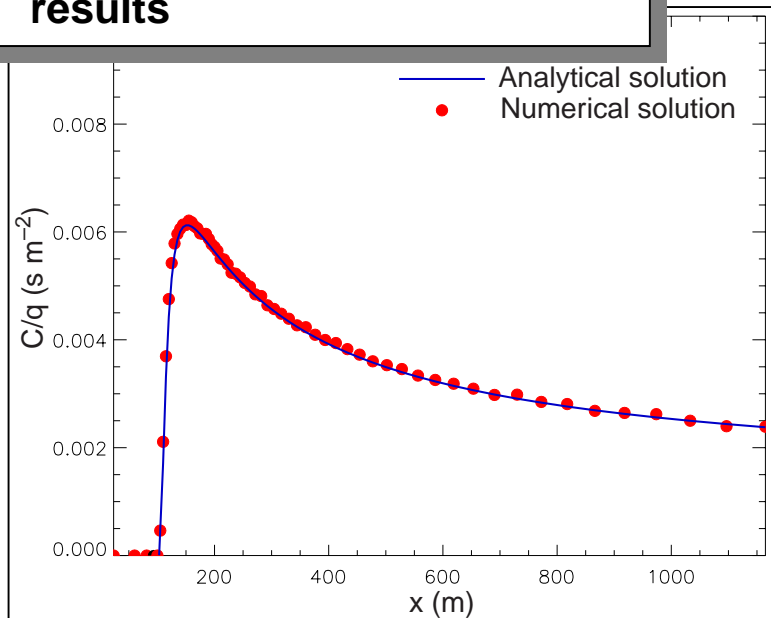


LLNL *KDFOC* buried-burst
nuclear fallout model



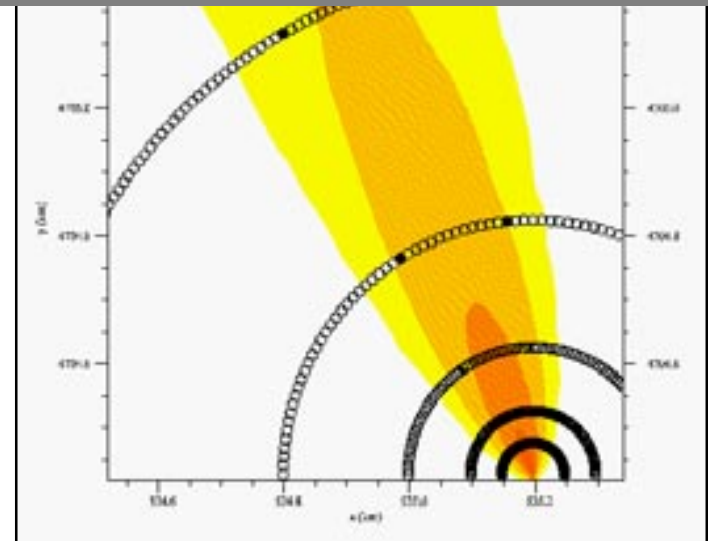
Validation and Evaluation

- **Analytic solutions** test models versus known, exact results



- **Field experiments** test models in real-world cases

Examples: Project Prairie Grass, Roller Coaster



LLNL and SNL Models have historically been evaluated using both analytic solutions and field experiments

Dose and Effects

- Standardizing on common dose factor databases for inhalation (functions of radionuclide, chemical form, and particle size) ground exposure and air immersion exposure modes (ICRP 26, 30, 60-series internal dosimetry models; Federal Guidance Reports 11, 12 & 13)
- Standardizing on SNL methods for using probit arithmetic to estimate acute/lethal dose probabilities
- Population data, lethal dose probabilities, and risk factors used to estimate fatality and injury counts

Products & Reports

Developing standardized products and reports:

- Geographical information displays
- Maps with hazard contours
- Input data assumptions
- Text, graphs and tables with summary of consequences, affected area, exposed population, and estimates of fatalities and casualties

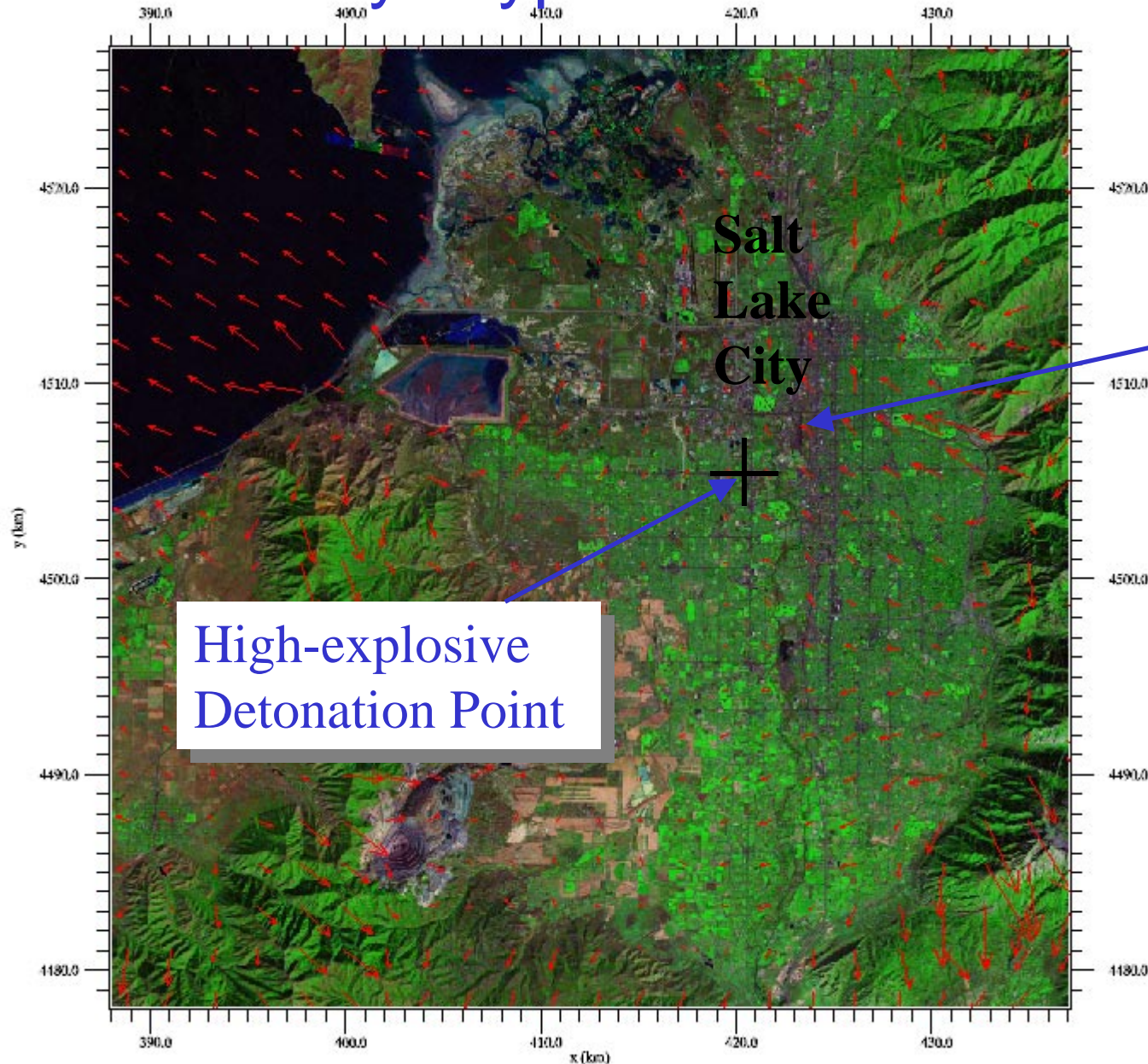


Figure 8: Radiation Exposure for 1 kt for Chronic Health Effects

Table 15: Radiation Exposure Contour Levels and Chronic Health Effects

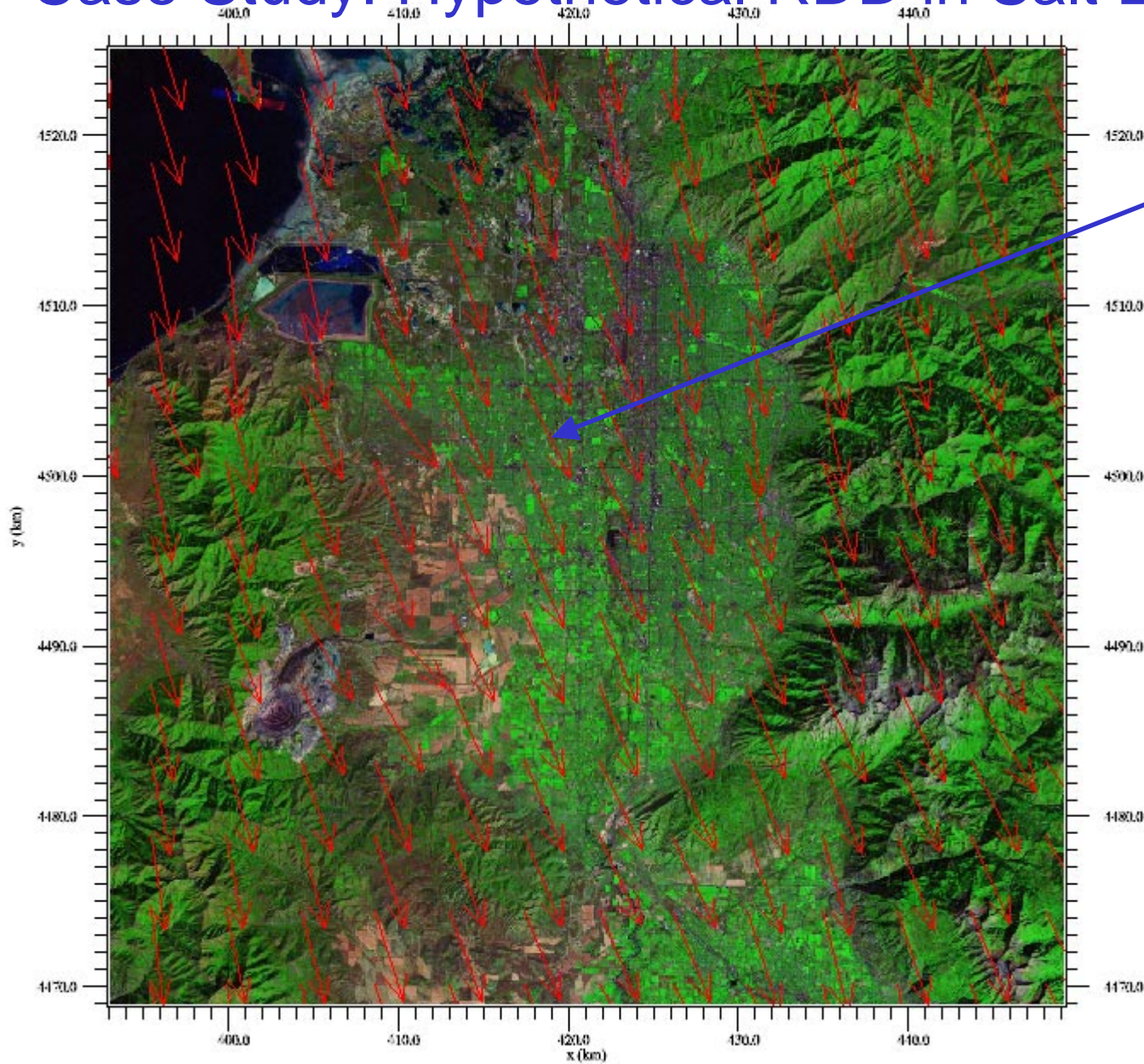
Level, rem	Description	Distance, km	Area, km ²	Population Exposed	Fatalities	Casualties
>1	Evacuation/Sheltering PAG (Lower)	34	670	1075776	8662	17324
>5	Evacuation/Sheltering PAG (Upper)	18	220	555284	8026	16052
>25	EPA Emergency Personnel Limit	8.9	69	195391	5965	11930

Case Study: Hypothetical RDD in Salt Lake City



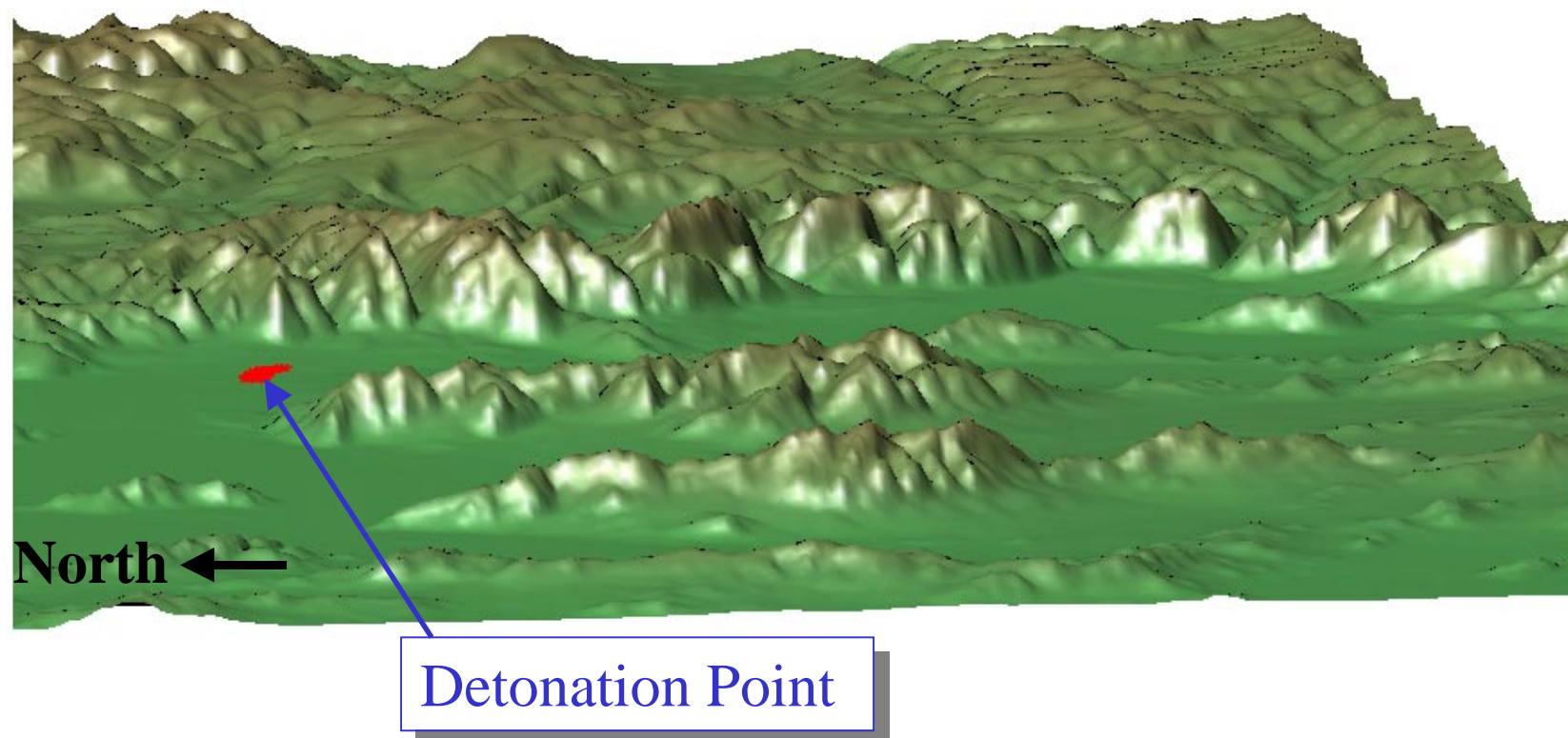
Jan. 30, 2002
Early morning
light near-
surface winds
show cold air
drainage flow
down slopes &
towards the
Great Salt Lake

Case Study: Hypothetical RDD in Salt Lake City (cont.)



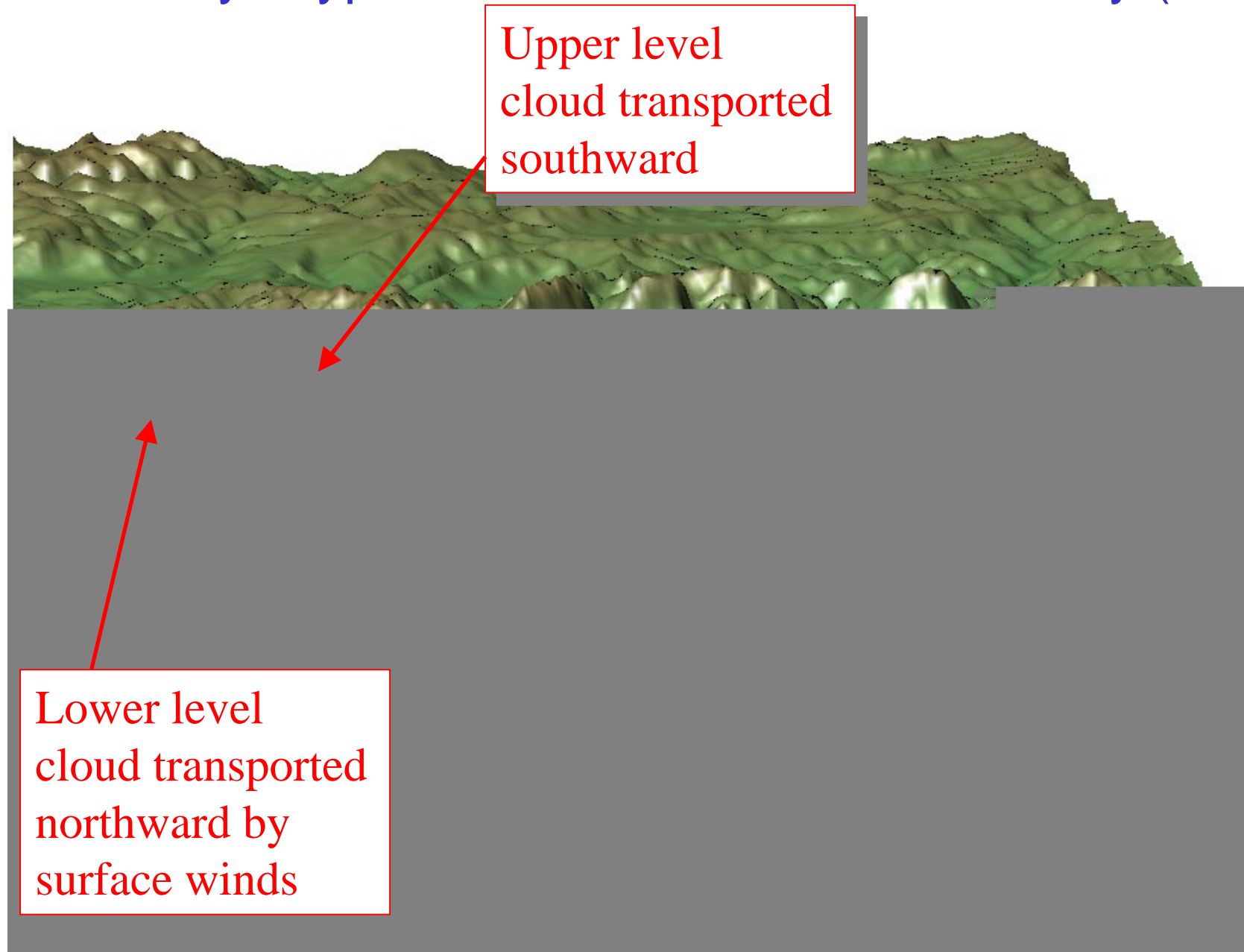
Stronger
Upper-level
winds from the
north above
detonation
point

Case Study: Hypothetical RDD in Salt Lake City (cont.)

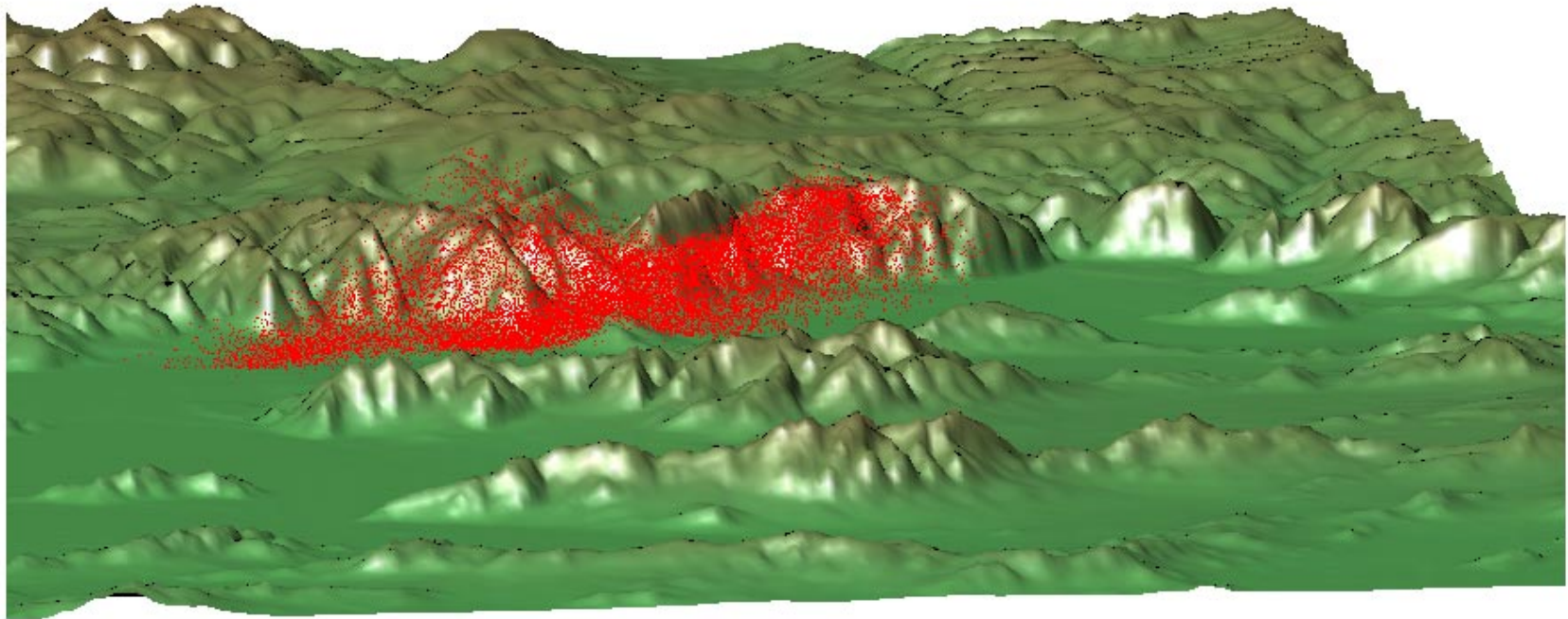


Red particles show LLNL NARAC ADAPT/LODI dispersion simulation using SNL ERAD explosive source characteristics (particle size distribution and spatial distribution of mass from surface to several hundred meters above ground)

Case Study: Hypothetical RDD in Salt Lake City (cont.)

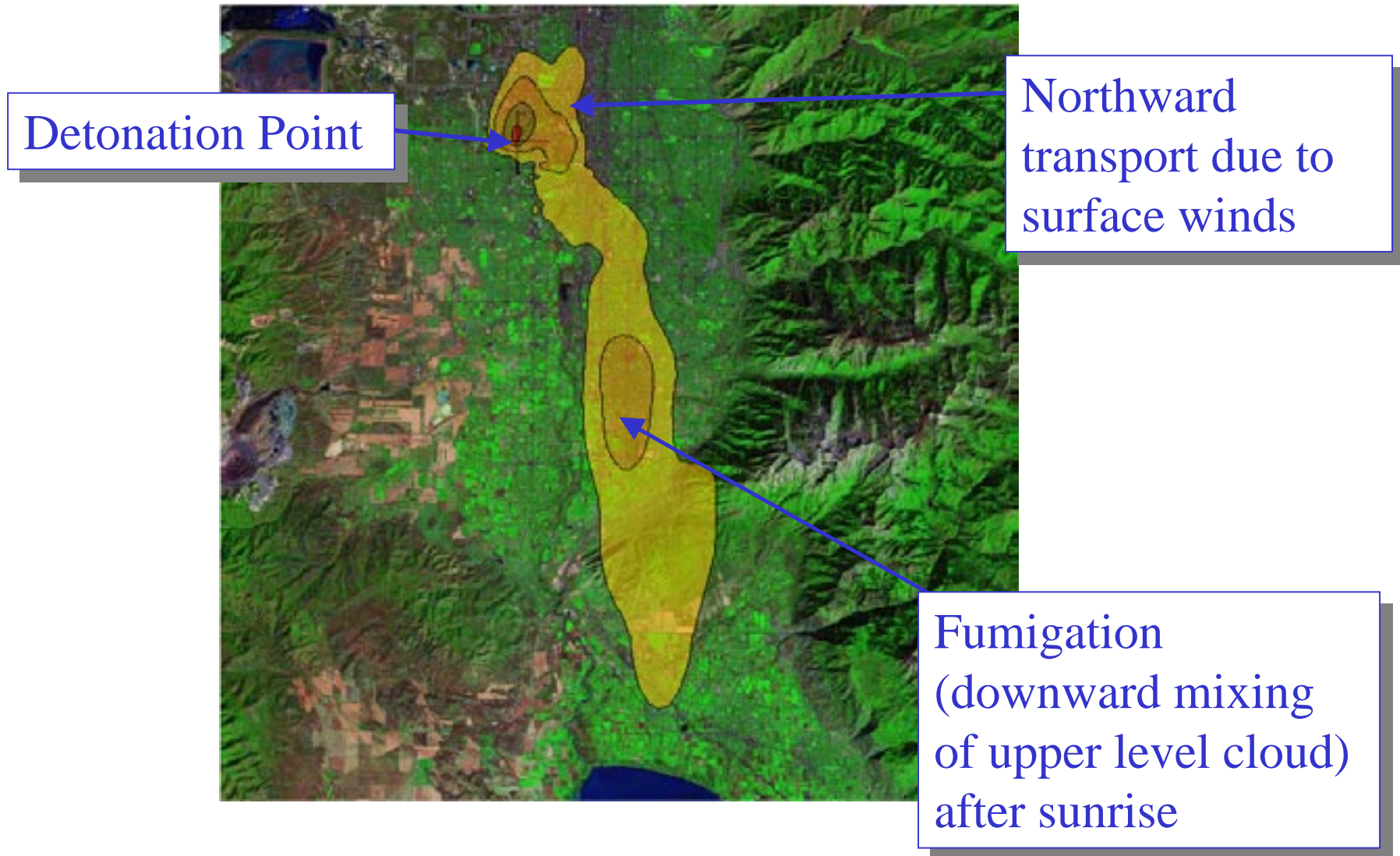


Case Study: Hypothetical RDD in Salt Lake City (cont.)



Increase mixing after daytime heating of surface occurs

Case Study: Hypothetical RDD ground- level time-integrated dose



Concept of Operations Summary

- Fast-running modeling and assessment tools for use by deployed teams
- Reach back to 3-D meteorological and dispersion modeling and feed of near-real-time meteorological data from national center (NARAC)
- Integrate with other agencies' emergency preparedness and response capabilities